2021 Chehalis ASRP
In-stream Wester Toad Survey Progress Report

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30 June 2021

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INTRODUCTION

The Western Toad (*Bufo = Anaxyrus boreas*) is a Species of Greatest Conservation Need (SGCN) under the Washington State Wildlife Action Plan (SWAP) and a Priority Species under WDFW's Priority Habitat and Species Program. It is also is one of nine non-fish species targeted in the Chehalis River Aquatic Species Restoration Plan (ASRP). In the Chehalis Basin, Western Toads engage in in-stream breeding during recessional flows before the dry season, resulting in lentic-breeding pools along typically large, sunny in-stream channels. This behavior of using stream networks to breed in the Chehalis Basin is unique and poorly explored as the species is generally considered as having a Stillwater life history. Carpenter (1953) and Metter (1961) observed Western Toads breeding along large-riverine habitats over a half-century ago,[1] but subsequent reports are sporadic. Nearly all citations are conservation assessments or reviews and most simply note Metter's original observations (Nussbaum et al. 1983, Maxell 2000, Davis 2002, McGee and Keinath 2004; but see Cavallo 1997 and Frissell and Cavallo 1997 for exceptions).

Formal surveys for Western Toads in the region have previously been sparse. Although in-stream breeding by Western Toads has been observed along the Satsop and Wynoochee Rivers, no records on the Chehalis River mainstem existed until recent work by WDFW (Washington Department of Fish and Wildlife [WDFW] WSDM database; Phil Peterson, pers.comm.).[2] During surveys in September 2001, (Caldwell et al. 2004), numerous Western Toad larvae were found near river mile (RM) 111.9 (river kilometer [RKm] 180.1) of the Chehalis River.[3] In August 2013, Western Toad larvae were detected during ASEP[4] fish surveys at RM 102.25 (RKm 164.2) and RM 118.5 (RKm 190.3; John Winkowski, pers. comm.) Subsequently in May 2014, our field crews sampling stream-associated amphibians near the Panesko Bridge observed Western Toad egg masses in a side pool connected to the mainstem. We then initiated systematic in-stream channel-margin surveys in May 2014 and continuing annually since. Through the 2020 field season, we have examined a total of 576.5 RM (925.9 RKm) of the Chehalis River mainstem and its major tributaries (**Figure 1**). Of this, we resurveyed approximately 64.3 RM (103.3 RKm) on subsequent visits to better inform inter-year variability in toad occupancy and abundance and confirm continuous use of areas such as those near the proposed dam site.

[1] Carpenter (1953) and Metter (1961) made observations, respectively, during the summers of 1951, and 1958-1960.
[2] The WSDM database is the WDFW wildlife records database.
[3] Vadas, Jr. returned to the same site on 30 September 2004 and found many Western Toad metamorphos on the floodplain. This location is roughly 2 RM [3.2 RKm] below the proposed dam footprint.
[4] Aquatic Species Enhancement Plan, now termed Aquatic Species Restoration Plan (ASRP).

These Western Toad in-stream amphibian surveys support ASRP goals by helping to identify occupancy and inform status and trend baseline patterns. This work also supports Programmatic Environmental Impact Statement (PEIS) and project-specific Environmental Impact Statement (EIS) development for a proposed flood retention project[5], evaluates selected potential changes in Western Toad in-stream habitat from flood control alternatives, and informs and prioritizes restoration efforts in the Chehalis floodplain. A critical goal of this work is to compare Western Toad breeding locations in the footprint of the proposed dam and reservoir to potential toad habitat elsewhere in the basin to estimate basin-wide impacts on Western Toad that flood control alternatives might create. This progress report updates efforts from 2014 through the 2020 field seasons and briefly describes those surveys and the pattern of distribution of in-stream breeding Western Toads in the Chehalis Basin.

METHODS

Reach Selection: We designed surveys to maximize coverage across the stream network. In 2014, our surveys expanded from our observation of Western Toad egg masses near the Panesko Bridge (just upstream of the proposed dam near Pe Ell). These surveys covered the entire in-stream area within the footprint of the proposed dam and reservoir upstream (hereafter footprint) on the mainstem Chehalis River and extended to the mainstem terminus at the confluence of the East and West Forks of the Chehalis River (**Figure 1, Figure 2**). Those surveys also included segments of major tributaries in the footprint with enough suitable breeding and rearing habitat to suggest Western toad presence, including Big, Crim, Lester, Roger, and Thrash Creeks (**Figure 1, Figure 2)**. In addition, we also surveyed downstream of the footprint as far as our sampling time window (see **Sampling**) allowed (**Figure 1, Figure 2**).

Because our observations of toad breeding in 2014 largely had open canopies, we hypothesized that suitable Western Toad habitat might reflect the degree of insolation, as linked to stream size. This hypothesis informed our survey reach selection in subsequent years. Our hypothesis is supported by work elsewhere on better-studied pond-breeding Western Toads which also use well-insolated environments (Karlstrom 1986, Crisafulli et al. 2005, Pearl and Bowerman 2006), such that tadpoles are found in warmer backwaters (Cavallo 1997, Frissell and Cavallo 1997; Carey et al. 2005). For this reason, we extended selection to habitats potentially suitable based on similarity in stream structure but that might be suboptimal because of less insolation. We accomplished this by extending surveys at least 1 mile (1.6km) into denser canopy enclosed areas, higher in the watershed. This approach allowed us to develop a preliminary understanding of how insolation might limit habitat.

[5] The proposed dam and reservoir for the FRFA alternative lies between RM 108.3 [RKm 173.9] and RM 116.6 [RKm 187.3]. The upstream end of this estimate is the full pool location of the reservoir surface (Footprint).

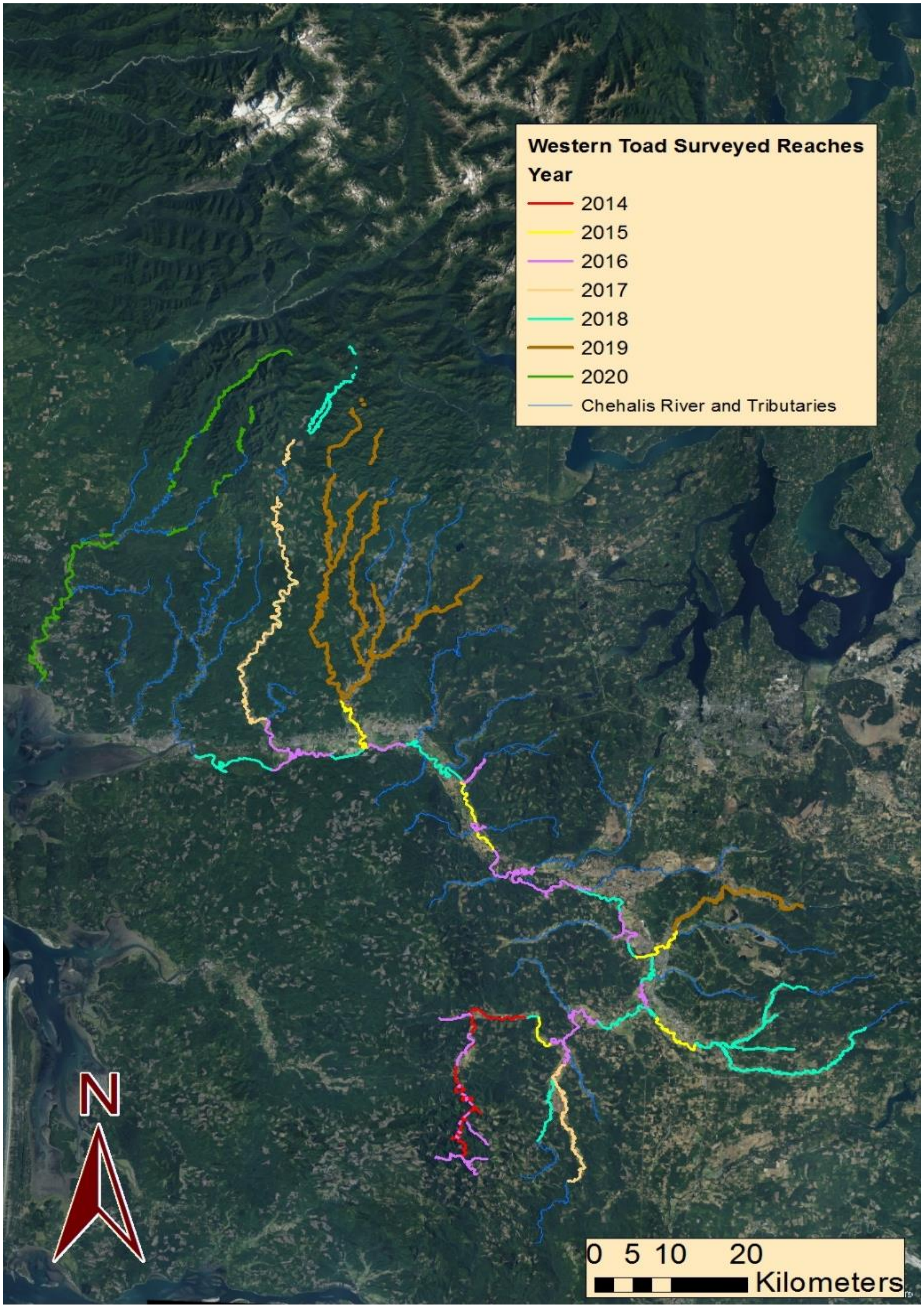
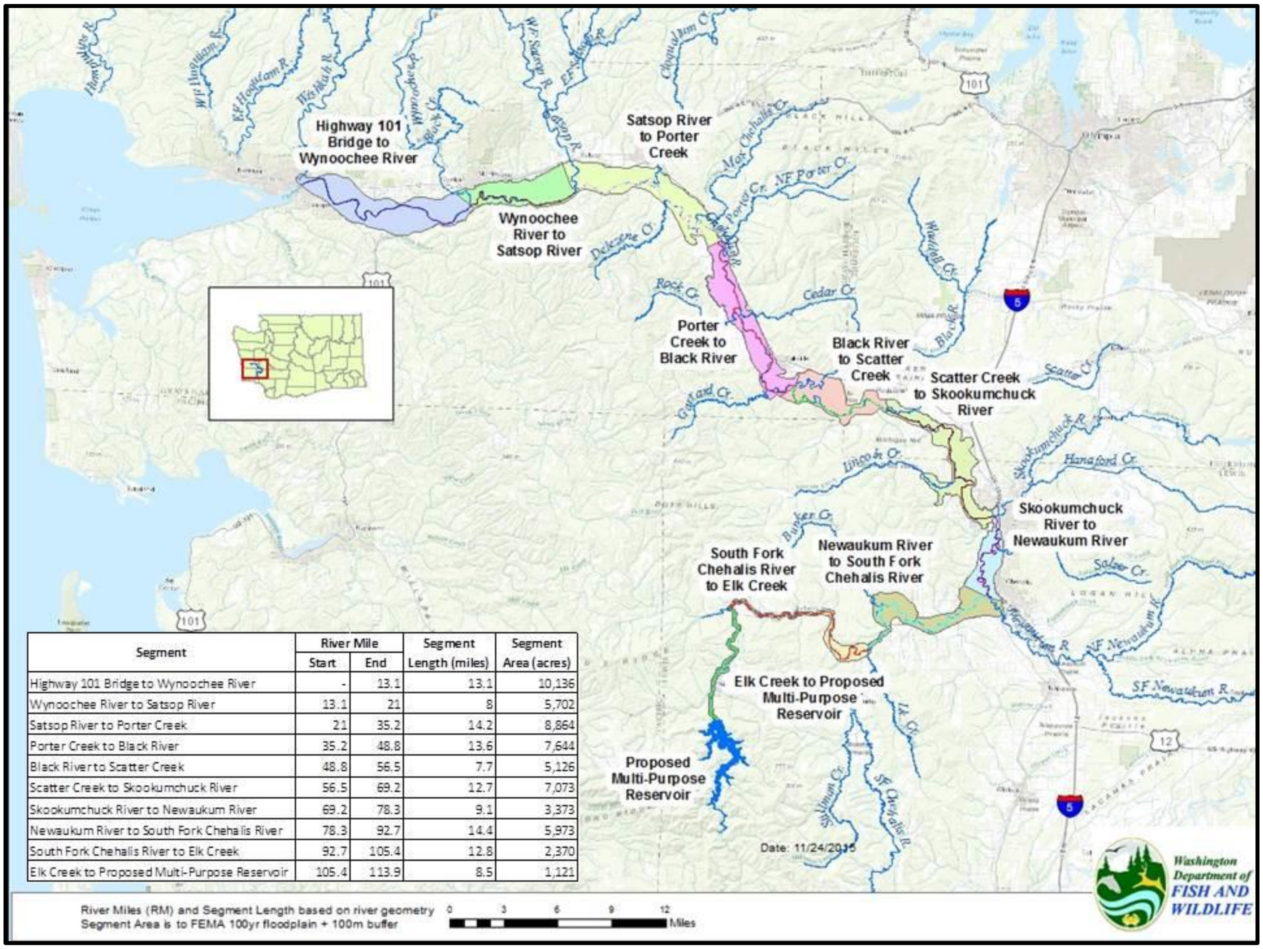


Figure 1. Instream survey reaches for Western toads for the years 2014-2020.



Segment	River Mile		Segment Length (miles)	Segment Area (acres)
	Start	End		
Highway 101 Bridge to Wynoochee River	-	13.1	13.1	10,136
Wynoochee River to Satsop River	13.1	21	8	5,702
Satsop River to Porter Creek	21	35.2	14.2	8,864
Porter Creek to Black River	35.2	48.8	13.6	7,644
Black River to Scatter Creek	48.8	56.5	7.7	5,126
Scatter Creek to Skookumchuck River	56.5	69.2	12.7	7,073
Skookumchuck River to Newaukum River	69.2	78.3	9.1	3,373
Newaukum River to South Fork Chehalis River	78.3	92.7	14.4	5,973
South Fork Chehalis River to Elk Creek	92.7	105.4	12.8	2,370
Elk Creek to Proposed Multi-Purpose Reservoir	105.4	113.9	8.5	1,121

Figure 2. Chehalis River mainstem segments used to stratify sampling of in-stream surveys.

In 2015, we sampled portions of four mainstem reaches and the lower portion of three mainstem tributaries: the Newaukum, Satsop, and Skookumchuck Rivers (4.7 RM (7.5RKm) (**Figure 1**). In 2016, we re-sampled selected areas to obtain a sense of inter-year variability and expanded surveys into unsampled reaches. With minor exceptions, resurveys consisted of a third of the footprint distance sampled in 2014 in 500-m long segments (**Figure 1**)[6]; and portions of the Chehalis mainstem between (a) Porter Creek and the Black River, and (b) Elk Creek and the footprint (**Figures 1** and **2**). New reaches surveyed were 2-8 miles (3.2-12.9 km) into the remaining river segments (**Figures 1** and **2**) and included tributaries we had not previously surveyed up to 6.5 miles (10.5 km) upstream from their Chehalis confluence. These tributaries included the Black River, Cedar Creek, Cinnabar Creek, Elk Creek, Independence Creek, Lincoln Creek, Porter Creek, Roger Creek, Scatter Creek, Wynoochee River, and the East, South, and West Forks of the Chehalis River.

In 2017, we focused our surveys on the Satsop, South Fork Chehalis, and Wynoochee Rivers to (a) confirm breeding locations found in those rivers in 2016; and (b) to survey as much area as

[6] Intervening spacer sections of 1000-m separated the sampled sections.

possible within the seasonal sampling window for those rivers (**Figure 1**). In 2018, we focused on completing previously unsurveyed areas of the mainstem Chehalis. In addition, we surveyed Stillman Creek and the Newaukum Basin. In 2019 we focused efforts on the Satsop River and the Skookumchuck River below the dam. In both 2018 & 2019 we resurveyed previously-surveyed regions of the Newaukum, Satsop, and Skookumchuk to assess inter-year variability. In 2020, we focused our efforts the Humptulips watershed where no surveys have been previously conducted; these surveys complete the last known occupied watersheds in the Olympics.

In 2021, our goal is to survey upstream of the Skookumchuck Dam, Hoquim River, and Wishkah River.

Sampling: Assessing toad breeding can be challenging because toads are explosive breeders that rapidly initiate and complete breeding at a given waterbody and because toad embryos and tadpoles develop rapidly. These life history traits mean that it can be easy to We used several indicators to guide when we initiated sampling for Western Toad breeding surveys using insight into the natural history surrounding the conditions that stimulate breeding and the length of the oviposition window. Particularly, we paid attention to river hydrographs based on Metter's (1961) suggestion that riverine Western Toads may delay initiation of breeding until flows subside to a level unlikely to wash away their eggs, which was corroborated by our field experiences in 2014. We therefore used the gauges most proximate to the area we planned to survey as guides. Hydrographs typically decline to a level suitable for breeding during mid-May to early June based on previous extensive surveys.[7] When the stream hydrographs appeared to reach a stable lower flow level, we would employ reconnaissance surveys to verify water levels and to search for toad activity.

We conducted Western Toad surveys with 2-5 surveyors. Survey reaches typically had an upstream entry point and surveyors worked downstream to an exit point. We surveyed all channel braids, if multiple braids were present, within a reach. Surveys were by visual encounter, where surveyors slowly walked and/or kayaked both margins of stream reaches, stopping to record all locations with evidence of recent Western Toad breeding (i.e., embryos [colloquially called eggs] or non-feeding hatchling tadpoles) or there was evidence of recent or eminent breeding (i.e., aggregated feeding tadpoles, metamorphosing toadlets, or adults congregating). We regarded breeding locations as separate locations if separated by at least three meters due to the wandering nature of Western Toad embryo [egg mass] strings. If we only identified free-

[7] First observed breeding dates for Western Toad in the Satsop drainage ranged from 12 May to 17 June based on 9 years of data. Variation reflects inter-year variability and location of surveys on either the West or Middle Forks of the Satsop River. The actual first-breeding date may be earlier in some cases because 16 of the 18 surveys (surveys were always done on both forks each year) the first-observed breeding date was also the first survey date. Though we had these data from the Satsop, we recognized that differences in behavior there compared to elsewhere in the Chehalis River network might result in breeding periodicity differences of Western toads in those places (cf. Carey et al. 2005; Reaser and Blaustein 2005).

swimming tadpoles in a pool, we considered the entire pool as the breeding location and did not record any oviposition sites.

At breeding locations, we recorded a suite of biotic data. If we found Western Toad egg masses, we estimated the number of masses based on the number of jelly strings with embryos divided by two (because each egg mass from a single female consists of two strings),[8] but also recorded the number of non-embryo life stages as larvae, metamorphs, juveniles, or adults.[9] We also recorded presence data on the other amphibian and fish species and invertebrate species that predate upon of tadpoles.[10]

Physical data of breeding pools recorded included location and structural features. Location data recorded were the GPS and RM (river mile; also river kilometer, RKm)[11] of each oviposition site, and the bank location (as right or left bank).[12] Structural features recorded were water depth, pool width, substrate composition, water velocity, water temperature, % canopy cover, and a description of connection to the riverine main channel if any. We scored substrate into five standard categories[13] and estimated each to the nearest 5% in a 1-m diameter circle centered on each egg mass. We also took photographs as an archive of conditions at the site at the time of the survey.

Starting in 2016, we also obtained a parallel set of data for a random location not used for Western Toad oviposition, but adjacent (within 5 m) to the oviposition locations.[14] We collected these data to understand how Western Toads might be selecting breeding and rearing habitat based on the key variables of depth, flow, and substrate within a given pool.

Data Handling and Analysis: We report Western Toad breeding data as either the number of breeding locations or egg masses per river mile where we obtained at least one breeding event (≥ 3m apart). Stream width increased with downstream position along the stream network, so these data represent indices of breeding location or egg mass densities rather than true area-based densities.

Identification of stream RM locations merits brief discussion because of uncertainty in describing current locations. Chehalis Basin investigators used USGS RM due to convenience,

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[8] Individual strings are recognizable by a 6-12-cm length of tapered jelly at each end of the string that does not contain embryos.

[9] Embryos (colloquially called eggs) are the pre-hatching life stage; larvae are post-hatching and pre-metamorphosis; metamorphs are at metamorphic climax (possess 3-4 legs and a tail); juvenile are non-adult post-metamorphs; adults are reproductive mature post-metamorphs.

[10] Key predatory invertebrates recorded were crayfish, giant water bugs, diving beetles, backswimmers, and water scorpions (cf. McCafferty and Provonsha 1981; Carey et al. 2005).

[11] Obtained from GIS post-processing to the nearest 0.10 mi (0.16 km).

[12] We evaluate right or left bank facing upstream.

[13] Fines (sand or smaller), gravel, cobble, boulder, and bedrock.

[14] We chose the adjacent location from a random direction, and random distance within 5 m of the center of the Western toad oviposition to the nearest cm, using random # generator. If this random adjacent location did not fall in water, we continued choosing a new random distance and direction until we found one that fell within aquatic habitat.

which originated from mapping developed for historic 7.5' topographic quadrangles.[15] However, stream migration has altered RM locations from the original USGS mapping through differential lengthening or shortening of local streams reaches (see Pierce et al. [2017] for a sense of the degree of local meandering over time here). For this reason, USGS RMs fail to generate precise distances in GIS-based distance calculations on current maps, and we found actual locations and distances could vary by as much as 0.5 mi (0.8 km). However, we based our measurements of survey distances with GPS tracklines and the NAIP map closest to the year of survey.

Initial analysis of oviposition density indices and habitat selection near the proposed dam were provided for the PEIS and EIS efforts. We used linear mixed effects models (treating each egg mass:pool combination as a random effect) to assess whether oviposition site characteristics varied among streams. In recent years, we also started collecting environmental data at a paired random point within 5m of each oviposition site. We also used mixed effects models to assess whether microsite variation differed between oviposition sites and paired random sites to begin assessing whether toads were selecting habitat features within pools in addition to across pools.

RESULTS

<u>Survey Effort</u>: Over 2014-2020, we surveyed 6-26 days within a time window of 21 to 63 days each year (**Table 1**). Between 2014-2020, our in-stream surveys have covered 576.5 RM (925.9 RKm), (**Figure 2**, **Table 1, Supplemental Tables 1-3**), these included 266.2 RM (427.5 RKm) in the Olympics region. Of our 576.5 RM, 64.3 RM (103.3 RKm) were resurveys (11.2%).

Total surveys include 12.0 RM (19.3 RKm) of the mainstem within the footprint (of which 2.8 RM [4.5 RKm] were resampled) and 2.9 RM (4.7 RKm) of tributaries within the footprint. In addition, we also surveyed upstream of the footprint 2.5 RM (4.0 RKm) in the Chehalis mainstem and 11.0 RM (17.7 RKm) in tributaries. Downstream of the footprint, we surveyed 132.2 RM (212.3 RKm) in Chehalis River mainstem (of which 15.5 RM [24.9 RKm] were resampled), and 415.9 RM (667.9 RKm) in tributaries (of which 46.0 RM [73.9 RKm] were resampled). Details by area and year can be found in **Supplemental Tables 1-3**.

*<u>Western Toad Breeding and Development Locations</u>***:** Combining all years (2014-2020) and all locations where we had breeding activity, we recorded 588 breeding locations and a minimum of 879 egg masses[16] in in-stream-associated habitats (**Table 2**). Besides main-channel habitats,

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[15] The Washington Department of Ecology created the Washington State GIS RM point layer in March 2007 by digitizing river mile points from the USGS 7½ minute (24k) topographic quadrangle maps created during the 1950s-1980s. Some of the rivers have gaps in the river mile progression because several quadrangle maps lack RM points, while a few were missing a point or two. In November 2014, Ecology added RM points for the missing areas using WDFW's 1975 Stream Catalog, which covered only WRIAs 1 through 24. The Stream Catalog showed RMs for nearly every stream; however, only those watercourses that have RMs from USGS quadrangle maps were added.

[16] This represents a minimum count given the likelihood of underestimating the egg mass number if the number of egg masses at an oviposition site exceeded three.

these included perennial side channels and connected backwaters, but not isolated (floodplain) backwaters (sensu Chamberlin and Humphries 1977, Vadas 1992, Vadas and Orth 1998). We recorded 222 breeding locations and 357 egg masses in stream networks associated with the Chehalis mainstem (**Figure 3 and Table 2**). We found the 366 remaining breeding locations and 522 egg masses in large tributaries draining the Olympics (**Figure 4 and Table 2**).

Table 1. Chehalis Basin Survey Effort for In-stream Amphibian Surveys, 2014-2020.

Year	Survey Dates		Days Surveyed	Miles (km)
	Start	End		
2014	28 May	28 July	17	28.7 (46.2)
2015	1 July	28 July	6	18.7 (30.1)
2016	9 May	15 June	15	26.1 (42.0)
2017	6 June	27 June	8	72.6 (116.8)
2018	21-May	3-Jul	17	90.9 (146.3)
2019	9-May	2-Jul	26	148.6 (239.1)
2020	10-Jun	12-Aug	21	58.8 (94.6)

We found no Western toad breeding sites in any of the small- to medium-sized tributaries of the upper Chehalis River mainstem except in the East and West Forks. Such smaller tributaries include Big, Cinnabar, Crim, Elk, Lester, Roger, and Thrash Creeks. All these streams except Big and Roger Creeks had either limited insolation, reflecting (a) riparian tree cover (more than 25% on average) or (b) limited or no shallow shelf structure typical of Western toad oviposition sites. Big and Roger Creeks appeared to have some open reaches with shelves, but whether the relatively smaller area with this habitat had flows low enough to allow oviposition is unclear.

Table 2. Total Breeding sites and egg mass counts organized by stream network for all surveys (including resurveys). All Mainstem Breeding was above RM 82 to the confluences of the East and West Fork Chehalis. Multiple breeding sites may be within the same pool.

River	Breeding Sites	Egg Masses
Mainstem Chehalis	205	338
West Fork Chehalis	5	5
East Fork Chehalis	9	10
South Fork Chehalis	2	3
Stillman	1	1
Humptulips	117	152
Satsop	178	261
Wynoochee	71	109

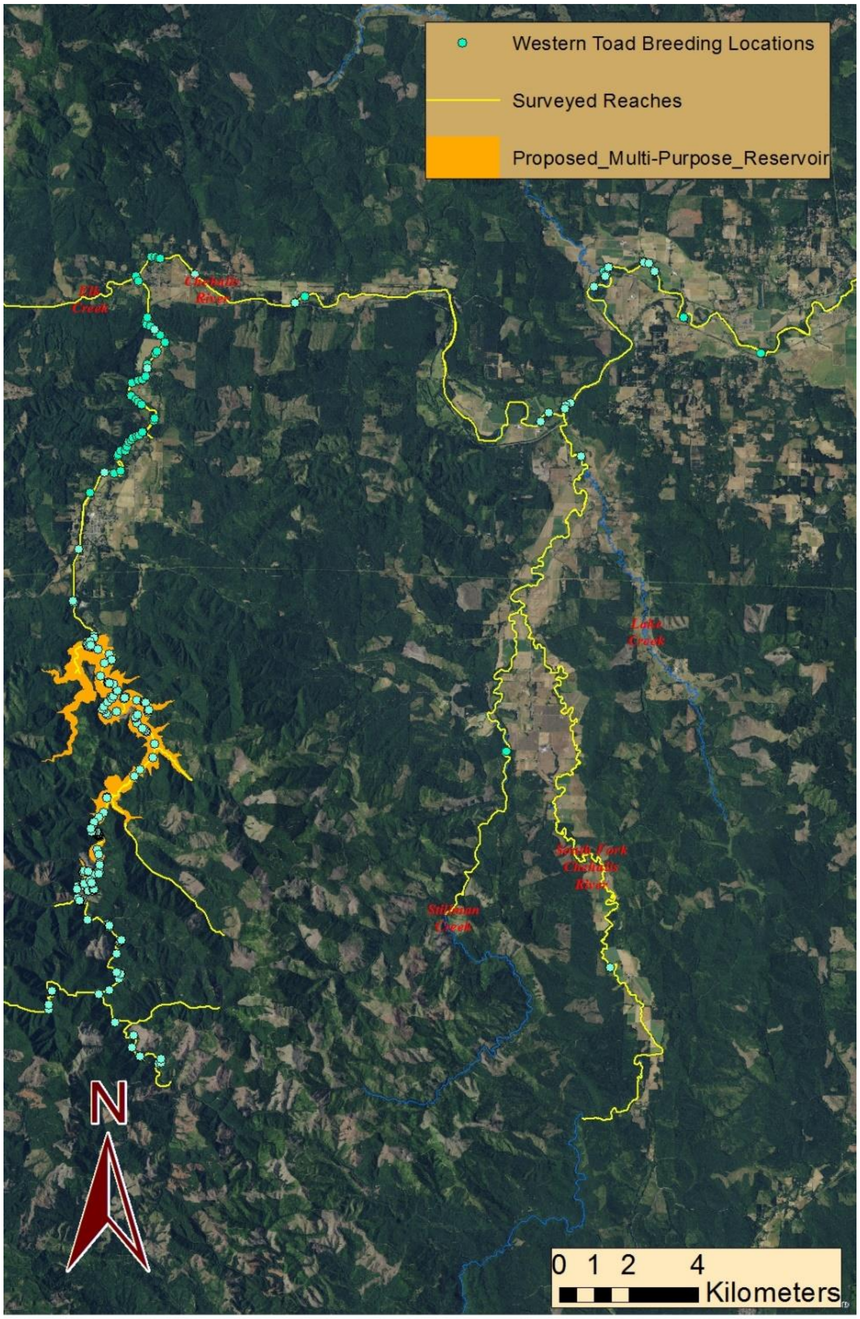

Figure 3. In-stream surveyed reaches and Western Toad breeding locations in the Upper Chehalis River Basin. A breeding location is defined by either presence of eggs, tadpoles, or recently metamorphosed toadlets.

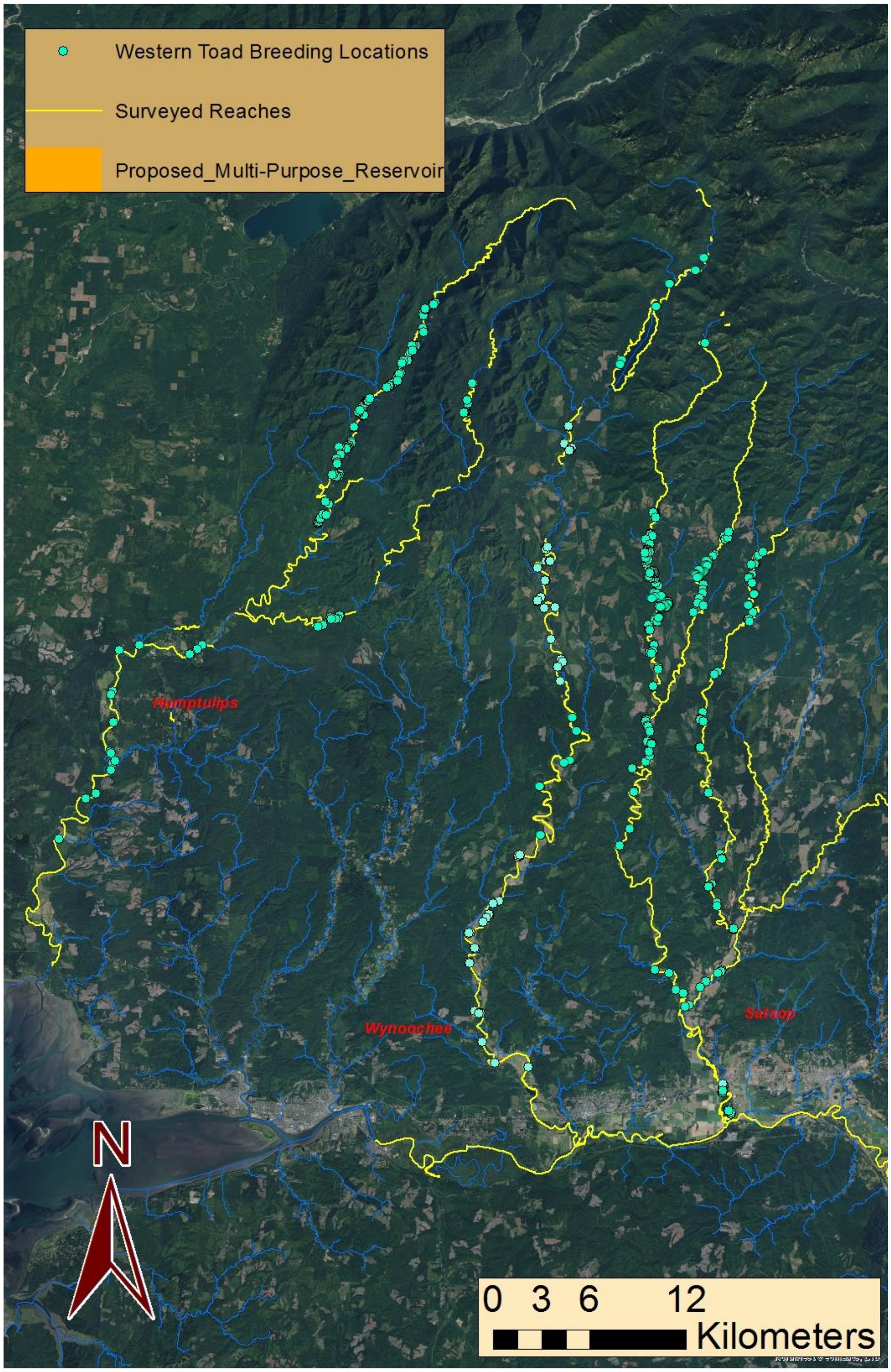

Figure 4. In-stream surveyed reaches and western toad breeding locations in the Olympics. A breeding location is defined by either presence of eggs, tadpoles, or recently metamorphosed toadlets.

Breeding Densities: Western toad breeding site and egg-mass densities varied by both region and locally with in each watershed. Here, we will briefly discuss the density indices for all cumulative survey distances across all years which includes repeated reaches.

Upper Chehalis Area: Within the upper Chehalis Mainstem region (between the confluence of the Newaukum River and the East and West Fork Chehalis), breeding densities varied widely among streams (**Figure 5**). For this report, we chose the cutoff for analyzing breeding densities in the Upper Chehalis area as between the confluence of the Newaukum River and East and West Fork Chehalis (RM 78.3). However, the last known egg mass breeding site was detected further upstream near RM 82.5 (**Figure 3**) which will increase the density measurements for this area. Breeding densities were highest in the Mainstem Chehalis and intermediate in the East and West Forks. The only other tributary in the upper watershed where we found western toad breeding was in the South Fork Chehalis (including Stillman creek) which had relatively low breeding densities (three breeding locations and four egg masses total; **Figure 5**).

Olympics Area: We found all the remaining Western Toad breeding exclusively in large streams draining the Olympics, namely the Humptulips, Satsop, and Wynoochee Rivers. Breeding densities for these streams were relatively similar and are also similar to the East and West Forks in overall population. The Humptulips was not completely surveyed in 2020 due to access issues and so overall breeding densities in this river may change with continued surveys.

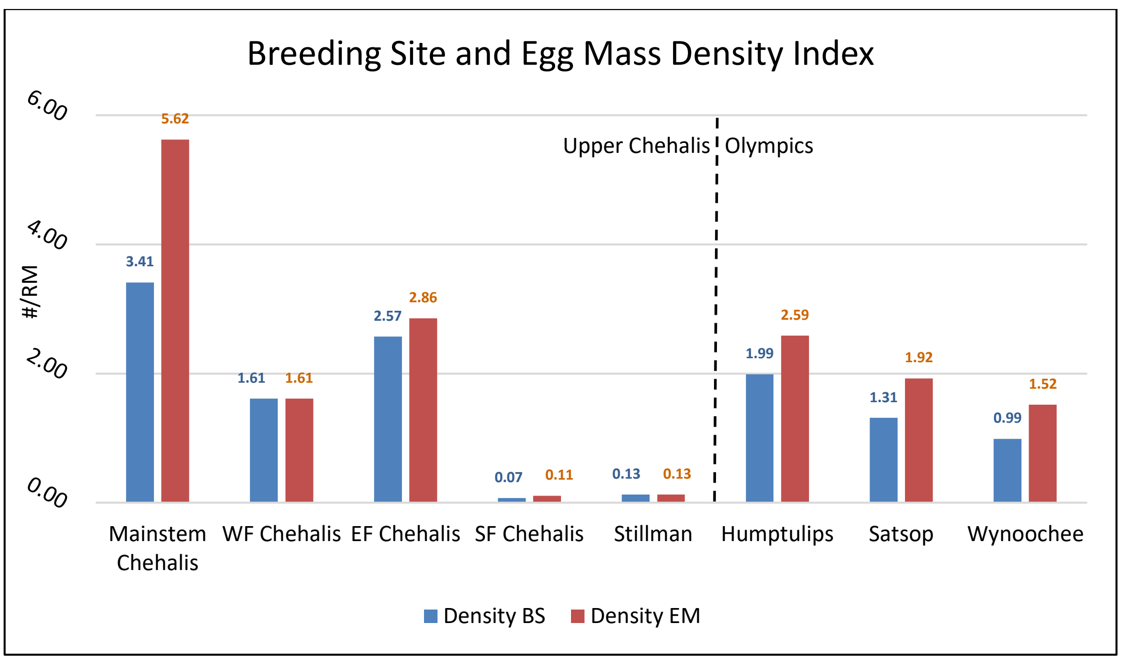

Figure 5. Western Toad breeding density for all cumulative survey distances across all years for both breeding sites (BS) and number of egg masses (EM) per river mile. The dashed vertical line separates Upper Chehalis Mainstem and Olympic drainages. Within the Upper Chehalis, the South Fork (SF) Chehalis and Stillman Creek had substantially lower breeding densities than either the West Fork (WF) or East Fork (EF) and Mainstem. Breeding densities in the Olympics were relatively similar across streams.

Proposed Dam Area Comparison: For years available for contrast in the vicinity of the proposed dam (2014 versus 2016), mean breeding densities within the footprint for both breeding-site mileage and egg masses were over an order of magnitude larger than below the footprint (**Figure 6**). Why toad breeding is concentrated in the proposed dam footprint is unclear and further environmental analysis is needed to clarify this issue, particularly with respect to land use variation and the availability of various in-stream habitats.

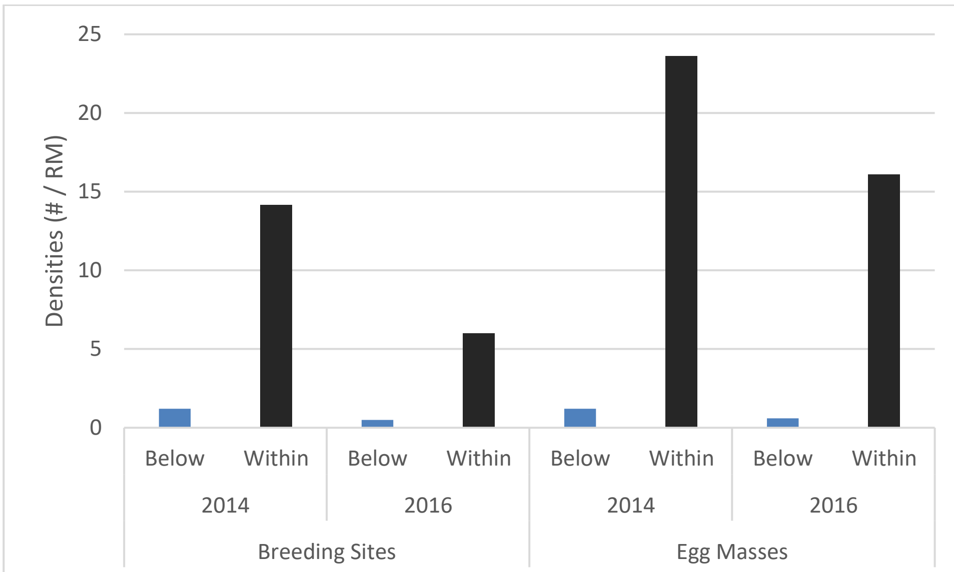

Figure 6. Breeding Site and Egg Mass Density Variation based on 2014 and 2016 surveys only.

Oviposition Habitat: We used linear mixed effects models with oviposition pool and egg mass as a random effect to assess differences in oviposition across rivers. In the subset of years for which we collected microhabitat data at random points within 5m of each located egg mass, we also analyzed whether environmental characteristics differed between oviposition sites and random sites, allowing us to gain better resolution into the habitat needs of breeding toads.

Data collected from 2016-2020 showed that Western toad oviposition pools had little canopy cover. A linear mixed effects model found that oviposition pools averaged 2.5% $\pm$ 4.3% SE canopy cover (**Figure 7A**). Although some rivers had oviposition pools with higher canopy covers (Figure 7A), canopy cover at breeding sites was not different among surveyed rivers ($p = 0.17$). A linear mixed effect model found that temperatures at oviposition sites were on average 21.9 degrees Celsius (SE 0.83). However, a Tukey's post hoc comparison showed that water temperatures varied across rivers ($p = 4.3e-12$; **Figure 7B**). In observing these differences, we performed a subsequent analysis with River and egg mass:oviposition pools as random effects to look at temperature differences among the two major drainages in our study: the Olympic (Humptulips, Satstop, and Wynoochee rivers) and Willapa (mainstem, East Fork, and West Fork Chehalis) drainages. We found that the Olympic toad breeding sites are 5.0 (1.45) degrees Celsius colder than Willapa toad breeding sites. This pattern largely corroborates prior temperature differences recorded in the Chehalis, particularly with respect to cooler, largely snow-fed streams in the Olympics and warmer, largely rain-fed streams in the Willapa region (Winkowski et al. 2018).

Toad oviposition sites within pools were shallow. A linear mixed effects model on 2017-2020 survey data found that Western Toad oviposition sites across rivers averaged 9.98 cm ± 0.71 SE in water depth. A likelihood ratio test on our mixed effects model found no difference in oviposition water depth among rivers (p = 0.37; **Supplemental Figure 1**). However, our model revealed that Western Toad oviposition sites were significantly shallower than random points (p = 2.29 e-15; **Figure 8**)[17], suggesting that toads are favoring shallower microhabitats within pools.

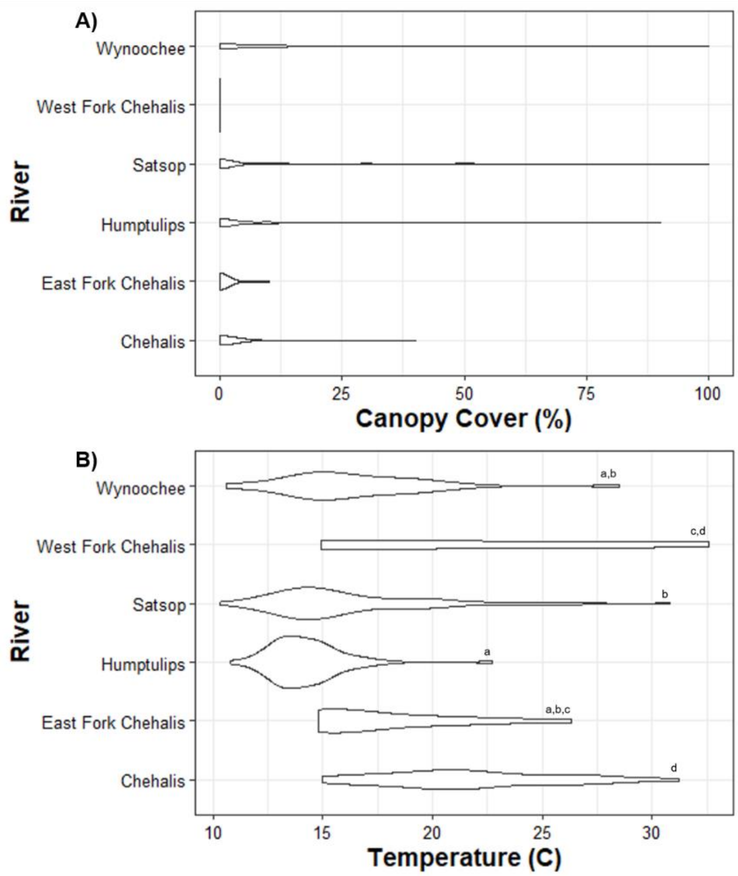

Figure 7. Variation in Canopy Cover (A) and Temperature (B) at oviposition sites among rivers in the Chehalis Basin. Canopy cover is generally low across oviposition sites and similar among rivers. Temperature is variable among oviposition sites and differs among rivers (letters are Tukey's post-hoc groups).

Our comparison of water velocity data with random points yielded similar results as depth. Western toads use oviposition sites with significantly slower water velocities than random points in the same pool (p = 1.97 e-09; **Figure 9**). Water velocities at oviposition sites were on average 0.003 cm/sec slower than random locations in the same pool. On average, velocities at oviposition sites were 0.001 cm/sec. Velocities at oviposition sites also differs among rivers (p = 0.01).

The maximum length, width, and depth of toad oviposition pools was similar among rivers (all p > 0.20). Although pool dimensions were variable, maximum length was typically below 50m, width below 10m, and depth was typically below 50cm (**Supplemental Figure 2**). Even so, some oviposition pools were substantially longer, wider, and deeper than average.

[17] We had depth data for oviposition points in 2016 but lacked depth data for random points to make the same comparison.

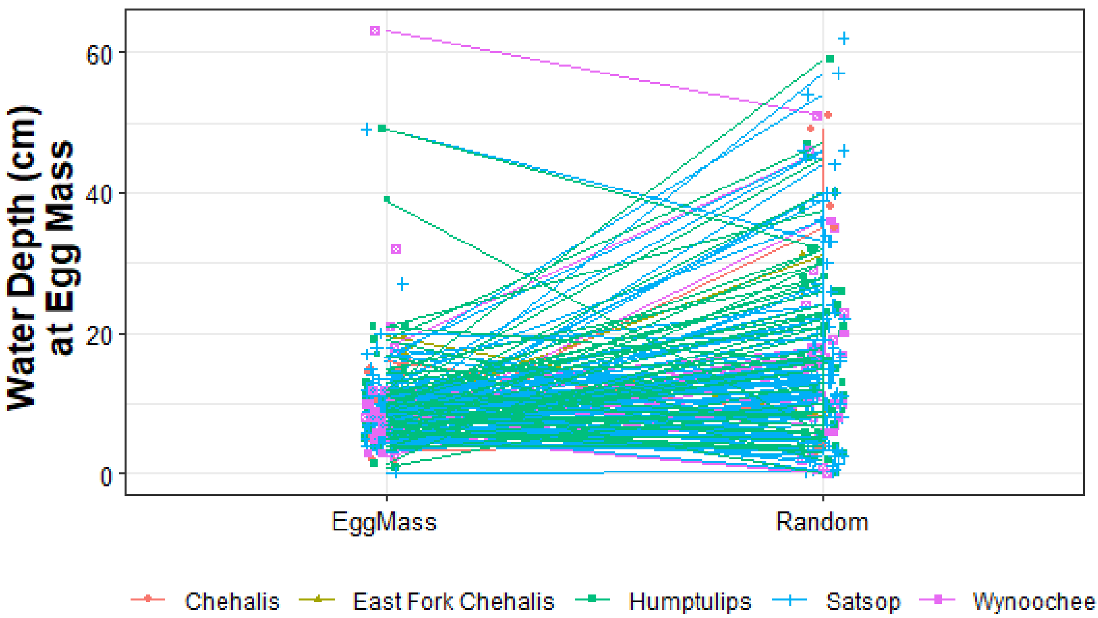

Figure 8. Water depth under egg masses at oviposition sites were consistently lower than at nearby paired random sites suggesting toads are selecting for shallower oviposition microhabitats within pools. Across rivers, toads rarely oviposited in water deeper than 20cm. Lines connect paired oviposition sites with nearby random sites in a pool.

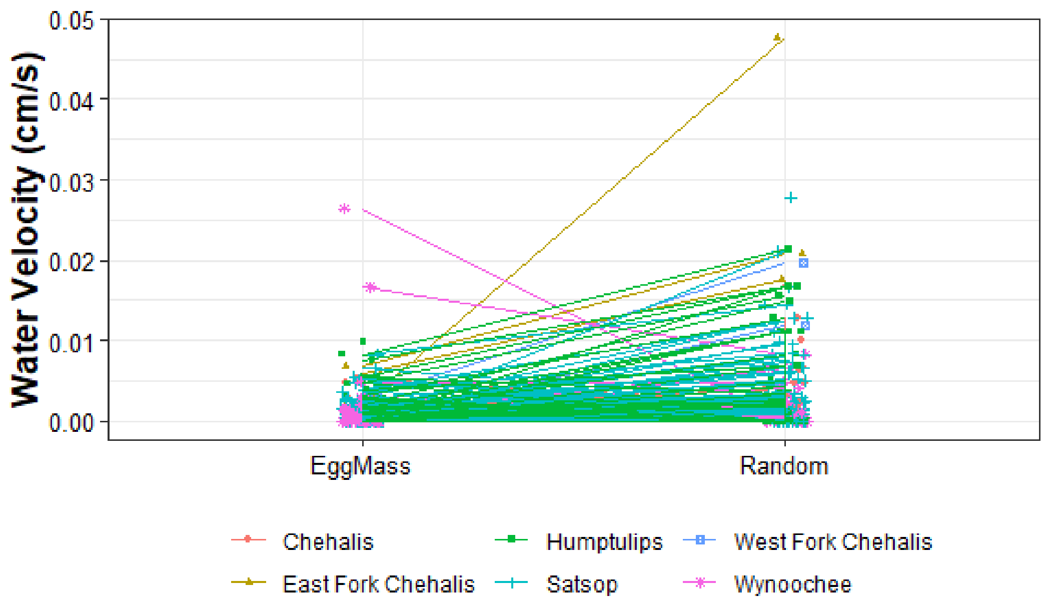

Figure 9. Water velocities at egg masses at oviposition sites were consistently lower than at nearby random sites suggesting toads are selecting for shallower oviposition microhabitats within pools. Across rivers, toads rarely oviposited in water velocities greater than 0.01 cm/s. Lines connect oviposition sites and nearby, paired random sites within pools.

Substrate variation at oviposition sites was variable but largely not different among rivers. Fine, cobble, and boulder substrate percentages at oviposition sites was variable among pools and did not differ among rivers ($p > 0.2$; **Supplemental Figure 3**). Gravel substrate percentage was also highly variable within and among rivers but a Tukey's post hoc test found significant differences among rivers ($p = 0.006$) with the Chehalis and West Fork Chehalis tending to have lower amounts of gravel, the Humptulips having higher amounts of gravel, and other rivers having intermediate amounts of gravel (**Supplemental Figure 3**).

<u>*Co-occurring Species*</u>: Across all pools with Western Toad breeding activity, we summarized incidental observations of other aquatic species. Pools where Western Toads breed also contain a diversity of other aquatic species including native amphibians (e.g., Pacific Chorus Frog [*Hyliola = Pseudacris regilla*], Rough-Skinned New [*Taricha granulosa*]) and a diversity of fish including Pacific Lamprey (*Entosphenus tridentatus*) and Northern Pikeminnow (*Ptychocheilus oregonensis*). Across rivers, roughly half (49%) of pools contained fish and most of these fish-bearing pools contained salmonids (43% of all pools) (**Table 3**). Although we could not always identify salmonids to species, Coho made up many of our salmonid incidental observations, occurring in 25% of all Western Toad breeding pools across rivers from 2016-2021 (**Table 3**).

Table 3. Total number of Western Toad breeding pools with fish present. When possible, fish were identified to salmon and specifically as Coho. Data only collected from 2016-2020.

	Connected			Disconnected		
	Pools with Fish	Pools with Salmon	Pools with Coho	Pools with Fish	Pools with Salmon	Pools with Coho
Chehalis	12	10	10	1	1	1
East Fork Chehalis	4	4	4	1	1	1
Humptulips	16	16	0	1	1	0
Satsop	30	17	6	5	4	3
West Fork Chehalis	0	0	0	0	0	0
Wynoochee	14	13	3	2	2	2

DISCUSSION and CONCLUSIONS

Our extensive surveying confirms that Western Toads in the Chehalis Basin overwhelmingly display an in-stream life history, a trait that largely contrasts with its biology elsewhere in its range. Based on the in-stream surveys reported here and studies in off-channel habitats in the mainstem Chehalis floodplain (Hayes et al. 2020) we have recorded Western Toad breeding in the lowland Chehalis Basin almost exclusively in in-stream-associated habitats.[18] Specifically, we have observed toad breeding in the upper one-quarter of the Chehalis mainstem length, some larger tributaries above there (East and West Forks Chehalis River), and a few larger tributaries of the middle and lower Chehalis mainstem (the South Fork Chehalis, Satsop, Wynoochee, and Humptulips Rivers).[19]

The lack of toad oviposition seen in floodplain off-channel habitats may reflect the typically well-shaded margins of off-channel habitats and/ or habitat modifications that steepen off-channel habitat margins, which eliminates their shallow footprints. We observed nearly all Western Toad breeding in well insolated, shallow stream margins. Such habitats do exist further from the main channel in the mainstem floodplain, but these are almost invariably in farmland production (Hamer et al. 2017). Whether these agricultural floodplain habitats are compatible with Western toad breeding is uncertain. Observation from a dryland region in central Oregon found that Western Toads rapidly colonized constructed ponds within a season for breeding suggesting that the species should fare well in similar habitats in the Chehalis (Pearl and Bowerman 2006).

Although some areas of the Chehalis Basin have not yet been surveyed for Western Toads, the emerging picture is that they are distributed in two general areas: 1) The upper Chehalis River mainstem and its tributaries, and 2) the large tributaries of the Chehalis Basin that drain the Olympics. Thus far, no breeding has been found in any of the rivers draining from the Cascades. If ongoing survey efforts in 2021 reinforces this pattern, it would raise the question of whether separation of Western Toads in these two regions is a recent or historical condition. Indeed, recent glaciation has influenced the Chehalis Basin (McPhail 1967). If the populations of Western Toads in the two regions are sufficiently distinct genetically, they may need additional protection and consideration under the ASRP. Although conditions where Western Toads breed in the Chehalis Basin are largely similar among rivers, water temperatures at toad breeding sites in the Olympics are substantially cooler than elsewhere in the Basin. This may suggest a degree of ecological separation between the Olympics and upper Chehalis region.

Flood Dam: Western Toad breeding is more extensive in the proposed dam and reservoir footprint than either up or downstream of this footprint. This difference was marked in the two years where it was compared (2014 and 2016) between the footprint and downstream (**Figure 6**). This may reflect juxtaposition of high-quality breeding and upland rearing habitat within the proposed footprint of the dam reservoir, and a potential contrast between a managed timber

[18] One historical record exists of Western toads breeding in an isolated, stillwater pond in the Chehalis Basin. This was a human-built, upland pond near Porter Creek, which was later filled in. We also found Western Toad breeding at one pond at the Briscoe site along the Wynoochee River that had a direct connection to the river and behaved more like a connected off-channel habitat. In addition, we found Western Toads breeding in Wynoochee Lake and a lake in the headwaters of the West Fork Satsop, both directly connected to the rivers.

[19] Elsewhere in western Washington (Joanne Schuett-Hames (personal communication) and other western states (Carey et al. 2005), Western toad occupy numerous highland lakes and ponds. Although such lentic habitats are rare in the Chehalis Basin, the few that exist have not yet been examined for Western toads.

landscape (potentially higher quality uplands for Western Toad) in the footprint and an agricultural landscape (potentially of lesser quality) below the footprint.

The proposed Chehalis dam has only one facility operation currently being considered, the Flood Retention Expandable (FRE). This option would retain water during flood events and release the water slowly after flooding subsides. Construction of the dam would likely eliminate instream breeding habitat in the footprint after flood events, as a large, deep stillwater pool would be replacing shallow instream habitat. Western Toads can breed in permanent reservoirs so it is possible that the FRE could add stillwater breeding habitat (Nussbaum et al. 1983, Wente et al. 2005, Joanne Schuett-Hames pers. comm.). However, the addition or extent of stillwater breeding habitat construction that could be added by the dam is unclear because the magnitude and timing of water level fluctuating resulting from dam operations and reservoir filling and emptying patterns may preclude Western Toad breeding[20]. If substantial water fluctuations (>6 inches [15 cm]) occur immediately post-breeding, Western Toad embryos could (a) die from stranding or physical disturbance with a water level drop, or (b) show impaired development or greater mortality from excessive water depth, where water temperature may be colder.

The FRE alternative would also reduce or eliminate suitable breeding habitat for Western toads for some unspecified distance downstream if cooler water outflow below the dam is maintained by water withdrawals from the hypolimnion (CBS – ASEP 2014). Cooler water delivered prior to breeding could delay (Carey et al. 2005) or deter breeding altogether, and cooler water during breeding could impair Western Toad development, thus increasing mortality. The magnitude of this effect, especially downstream, is dependent on how cool the released water may be, its volume, and its timing. We note that our findings show that Western Toads will breed in waters in the Olympics that are 5 degree Celsius colder than what is observed in the upper Chehalis and so some degree of breeding plasticity may help Western Toads tolerate cooler water released from the dam. The FRE alternative would also reduce or eliminate suitable habitat for Western Toad for some unspecified distance downstream if discharge from the dam is maintained at a level somewhat higher than what is seasonally typical. Western Toads normally lay unattached eggs in strings (Nussbaum et al 1983) and do not tolerate flow except at lower levels.[21] Hence, unless reproduction shifted mostly to floodplain wetlands, even a relatively small increase in flow level may prevent breeding or move embryos into shaded habitats that are unsuitable for development. Because dam releases for temperature reduction would invariably involve an increase in flow, the effects of flow and temperature are intertwined. Lastly, even if Western Toads could undergo such a behavioral

[20] Notably, the Western Toad population farther north in Lake Cushman reservoir is subjected to daily fluctuations under 1 m during non-winter seasons (Joanne Schuett-Hames and Peggy Miller, personal communication). However, Western Toad embryonic survival and early larval rearing under those conditions has not been evaluated.

[21] Precise threshold flows and water velocities that deter Western Toads oviposition is unknown, but are thought to be somewhat higher than water velocities measured at main channel oviposition sites in this study, and somewhat lower than random points at which no Western Toad oviposition was found.

shift to floodplain wetlands, floodplain wetlands are extremely limited in the upstream mainstem floodplain, so lack of proximate suitable Western Toad breeding habitat may prevent colonization success with such a shift.

Similar to the FRE, superimposing climate change effects on the anticipated responses of Western Toads adds further uncertainty, but positive responses seem unlikely. Also, the presence of the FRE footprint would result in some degree of isolation of the upstream populations from those further downstream periodically.

No Action: We might expect the no-action alternative to maintain the status quo, that is, the current distribution and population structure of Western Toads in the Chehalis Basin. However, there are two caveats: varying effects resulting from climate change and lack of understanding of dynamics linked to the historic timeline. First, climate change in western Washington is predicted to increase rainfall, seasonal precipitation variability, and frequency of extreme events resulting from rainfall (Mote and Salathé 2009). Flow variability and/or extreme flow levels will subsequently increase (Milly et al. 2008, Salathé et al. 2014) and, over the long-term, this might cause a decline in survival of the pre-metamorphic (embryonic and tadpole) life stages of Western Toads. We would expect the magnitude of this pattern to increase progressively over time unless human efforts ultimately change the climate change trajectory dramatically. However, increased thermal variability and exacerbated temperature extremes in streams from climate change (Milly et al. 2008), might partially counteract such population declines because Western Toads are warm-adapted (Carey et al. 2005).

Lack of understanding of dynamics linked to the historic timeline relates to the fact that the large-magnitude, wet-season freshets of 2007-2009 (WDRC 2014) moved large amounts of wood and rock (Nelson and Dubé 2016) that scoured many areas of the upper Chehalis River mainstem to bedrock (Robert Bilby, Andrew Kroll, personal communication). This condition may have increased available habitat for Western Toad oviposition, resulting in the high breeding site and egg-mass density indices we currently observe in that area. If this were the case, we would expect available oviposition and rearing habitat to decline somewhat over time as riparian vegetation develops and succession proceeds. This pattern would continue until the next large magnitude freshet, which should result in another scouring event that resets succession. Though this would likely be a fluctuating pattern over time, we expect the magnitude of that fluctuation to increase under an unaltered climate change trajectory. This might slowly degrade Western toad populations over time if riparian disturbances become excessively frequent or intense.

If one considers alternatives in the context of an unaltered climate-change trajectory, all alternatives are likely to have negative effects on Western Toad. Indeed, we expect that the no-action option would ultimately exhibit negative effects given climate change. This will be compounded because a dam option will likely cause some degree of isolation between upstream and downstream population. The dam alternative could contribute to the loss of a significant proportion of Western Toad populations in the lowland Chehalis Basin, as no significant breeding of Western Toad occurs downstream of the upper river and larger tributaries that are often in the proposed dam and reservoir footprint.

Restoration or Mitigation: To date, habitat restoration for in-stream breeding Western Toads has yet to be attempted; and available data make it unclear what restoration options are possible. Specifically, if we find upland habitat along the large-riverine Chehalis mainstem to be limiting because of lesser suitability, restoration improving its suitability to Western Toads may be possible. On the other hand, if hydrological or geomorphic factors limit Western Toads in the middle/lower mainstem, that restoration approach may not be available. What hydrologic, geomorphic, and biotic factors (e.g., predation and disease [Carey et al. 2005; Reaser and Blaustein 2005]) may be limiting need further research to determine what alternative restoration options may be possible. Further, whether mitigation for Western Toads within the reservoir is even possible under the FRE is uncertain. Further analysis of results will hopefully inform the viability of any restoration or mitigation options. Our analyses here and in the future may reveal which habitat features could be manipulated to restore Western Toads and their associated fauna (particularly salmonids like Coho). If floodplain backwaters are too shaded (cold) for Western Toad breeding (Cavallo 1997, Frissell and Cavallo 1997), then partial timber harvest or prescribed fire could potentially enhance toad populations.

Our analyses indicate that Western Toads breed in in-stream pools with a diversity of dimensions, depths, temperatures, and substrates. Even so, our analyses suggest that Western Toads appear to favor microhabitats within pools that are shallow (below 20cm and often below 10cm deep) and slow moving (typically below 0.001 cm/sec). Future restoration activities targeted at toads may benefit from targeting sites with these microhabitat conditions. We note, though, that our surveys were designed only to document pools where toads were present and so we do not have the data to characterize pools where toads are apparently absent. Although our current data can inform the environmental distribution of inhabited toad pools, they cannot inform how environmental features across the landscape shape the distribution of toads in the Chehalis Basin. Whether toad pool use is proportional to availability on the landscape or whether certain environmental features are selected by toads or limit toad success remains an unanswered but important question for managing toads under the ASRP.

Although Western Toads are better known as stillwater breeding species and do breed in stillwater habitats elsewhere in Washington, they appear to be primarily in-stream breeders in the Chehalis Basin. Why this life history variation occurs remains unclear, especially given the abundance of off-channel habitats, although many of these off-channel habitats are largely shaded or open but within agricultural fields. Work in central Oregon's dryland habitats has demonstrated that Western Toads rapidly colonize constructed ponds within a single season after pond construction (Pearl and Bowerman 2006). It is possible that constructing ephemeral pond and wetland habitats in the Chehalis Basin may be a potential restoration effort for Western

Toads, regardless of any decision surrounding the dam. However, such efforts may not provide co-benefits to co-occurring species like Coho salmon but may also provide habitat for other stillwater species.

Next Steps: Our ongoing work includes completing surveys of the Humptulips River in areas we had not acquired access for, Hoquim River, Wishkah River and the area above the Skookumchuck Dam. At the completion of the 2021 field season, we are collaborating with a doctoral student to model landscape variables associated with Western Toad breeding. Future work should also seek to determine genetic variation throughout Chehalis Basin toad populations, particularly to determine whether there is any substantial population structure between the Olympic and upper Chehalis River mainstem units. Additionally, continued trends analysis for Western Toads should also better untangle the associations between

Acknowledgements – The State of Washington Chehalis Initiative provided funding for this work. Weyerhaeuser, Green Diamond, Panesko Tree Farms and many other private and public landowners provided site access. Sarah Ashworth, Bonnie Blessing, Wesley Bowens, Keith Brady, Angela Brear, Chris Capelli, Sarah Coven, Kaysie Cox, Hannah Flotlin, Sebastian Ford, Caitlin Harris, Chris Holcomb, Lameace Kalisz, Jacob Layman, Noel LeRoy, Stephanie Lewis, Caitlin McIntyre, Amber Mount, Tara Newman, Sandy Patnode-Parrish, Kelly Perry, Kara Randall, David Reavill, Hope Rieden, Justin Roberts, Claire Satterwhite, David Snyder, Noll Steinweg, Panos Stratis, Larissa Swanson, Nick Wegener, Kerri Wheeler, and Kevin Young helped collect these data.

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Supplemental Tables

Supplemental Table 1. Mainstem survey summary for in-stream surveys partitioned by river segments, 2014-2019, there were no mainstem surveys in 2020. Survey distances are in river miles (RM) and river kilometers (RKm). Inundation footprint (or footprint) refers to the footprint of the proposed dam and reservoir at full pool.[22] Resurveyed stream distances are those that were resurveyed in a different year, unique stream distances are those surveyed only once.

		2014	2015	2016	2017	2018	2019	Resurvey	Unique
Survey Unit	**Segment Name/#**	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)
Mainstem Inundation	Reservoir	9.2 (14.8)		2.8 (4.5)				2.8 (4.5)	9.2 (14.8)
Mainstem Non-Inundation Upstream	Mainstem Up	2.5 (4.0)						0.0 (0.0)	2.5 (4.0)
Mainstem Non-Inundation Downstream	Mainstem Down							-	-
Wynoochee to Bridge	1			2.1 (3.3)		10.8 (17.4)		1.1 (1.8)	11.8 (19.0)
Satsop to Wynoochee	2			7.6 (12.2)		3.4 (5.5)		2.7 (4.3)	8.3 (13.4)
Porter to Satsop	3		0.8 (1.2)	3.5 (5.6)		10.6 (17.0)		0.4 (0.6)	14.5 (23.3)
Black to Porter	4		10.6 (17.0)	5.9 (9.6)				3.0 (4.8)	13.5 (21.7)
Scatter Cr to Black	5			9.0 (14.4)				0.8 (1.3)	8.2 (13.2)
Skookumchuck to Scatter Cr	6		1.3 (2.0)	2.7 (4.4)		8.2 (13.2)	0.3 (0.4)	1.6 (2.6)	10.9 (17.5)
Newaukum to Skookumchuck	7			4.9 (7.9)		4.9 (7.9)		0.0 (0.0)	9.8 (15.8)
South Fork Chehalis to Newaukum	8			7.5 (12.1)	0.6 (1.0)	10.5 (16.9)		1.3 (2.1)	17.3 (27.8)
Elk Creek to South Fork Chehalis	9	5.6 (9.0)	3.6 (5.8)	2.2 (3.5)		2.7 (4.4)		0.3 (0.5)	13.8 (22.2)
Dam to Elk Creek	10	8.6 (13.8)		4.3 (7.0)				4.3 (6.9)	8.6 (13.8)
Sum Total Segments		14.2 (22.8)	16.3 (26.0)	49.7 (80.0)	0.6 (1.0)	51.1 (82.3)	0.3 (0.4)	15.5 (24.9)	116.7 (187.8)
Sum Total all Mainstem		**25.9 (41.6)**	**16.3 (26.0)**	**52.5 (84.5 0**	**0.6 (1.0)**	**51.1 (82.3)**	**0.3 (0.4)**	**18.3 (29.5)**	**128.4 (206.6)**

[22] The proposed dam and reservoir for the FRFA alternative lies between RM 108.3 [RKm 173.9] and RM 116.6 [RKm 187.3]. The upstream end of this estimate is the full pool location of the reservoir surface (Footprint).

Supplemental Table 2. Tributary survey summary for in-stream surveys within or upstream of the inundation footprint from 2014-2017 (no surveys after 2017 in these areas). Survey distances are in river miles (RM) and river kilometers (RKm). Footprint refers to the footprint of the proposed dam and reservoir at full pool. There were no resurveyed areas and unique stream distances are those surveyed only once.

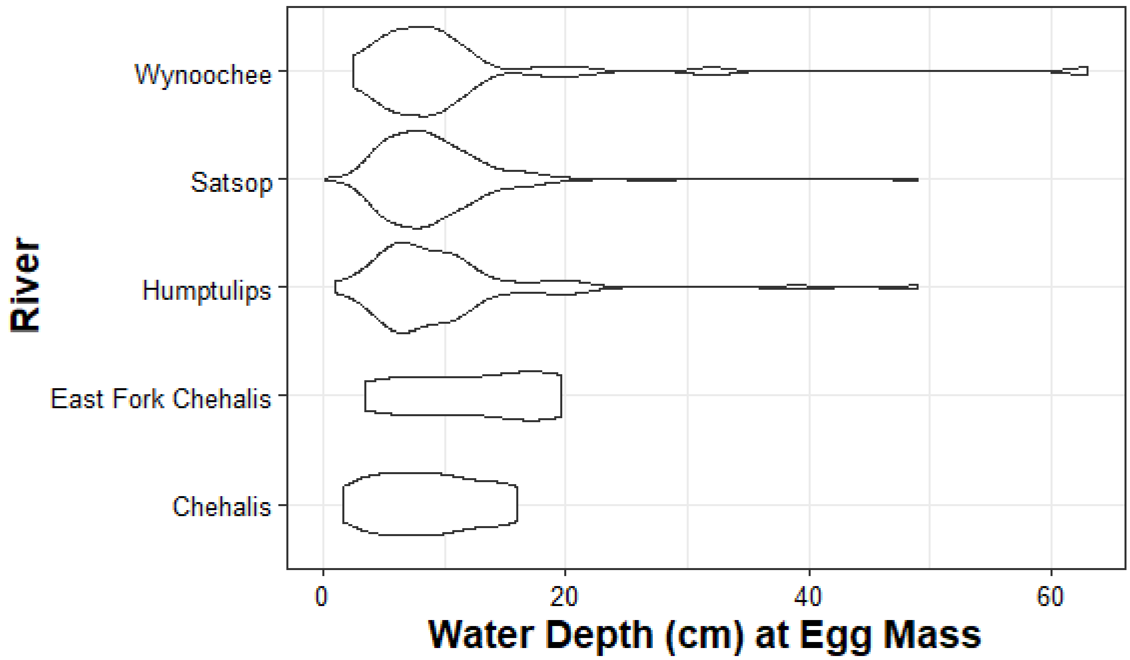
Survey Unit	2014	2015	2016	2017	Unique
	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)
Big Creek	0.9 (1.4)				0.9 (1.4)
Crim Creek	0.7 (1.2)				0.7 (1.1)
Lester Creek	0.1 (0.2)				0.1 (.2)
Roger Creek	0.4 (0.6)				0.4 (0.6)
-Big Roger Creek			0.4 (0.6)		0.4 (0.6)
Thrash Creek	0.4 (0.6)				1.1 (1.8)
Within Footprint Subtotals	**2.5 (4.0)**	**0.0 (0.0)**	**0.4 (0.6)**	**0.0 (0.0)**	**2.9 (4.7)**
Cinnabar Creek			1.8 (2.9)		1.8 (2.9)
East Fork Chehalis			3.5 (5.6)		3.5 (5.6)
Big Roger Creek			2.5 (4.0)		2.5 (4.0)
Thrash Creek	0.1 (0.2)				0.1 (0.2)
West Fork Chehalis			3.1 (4.9)		3.1 (5.0)
Upstream of Footprint Subtotals	**0.1 (0.2)**	**0.0 (0.0)**	**10.9 (17.4)**	**0.0 (0.0)**	**11.0 (17.7)**

Supplemental Table 3. Tributary survey summary for in-stream surveys downstream of the inundation footprint, 2014-2020. Grand totals are drawn from Table 1 and Supplemental Tables 1 and 2. Survey distances are in river miles (RM) and river kilometers (RKm). Resurveyed stream distances are those that were resurveyed in a different year, unique stream distances are those surveyed only once.

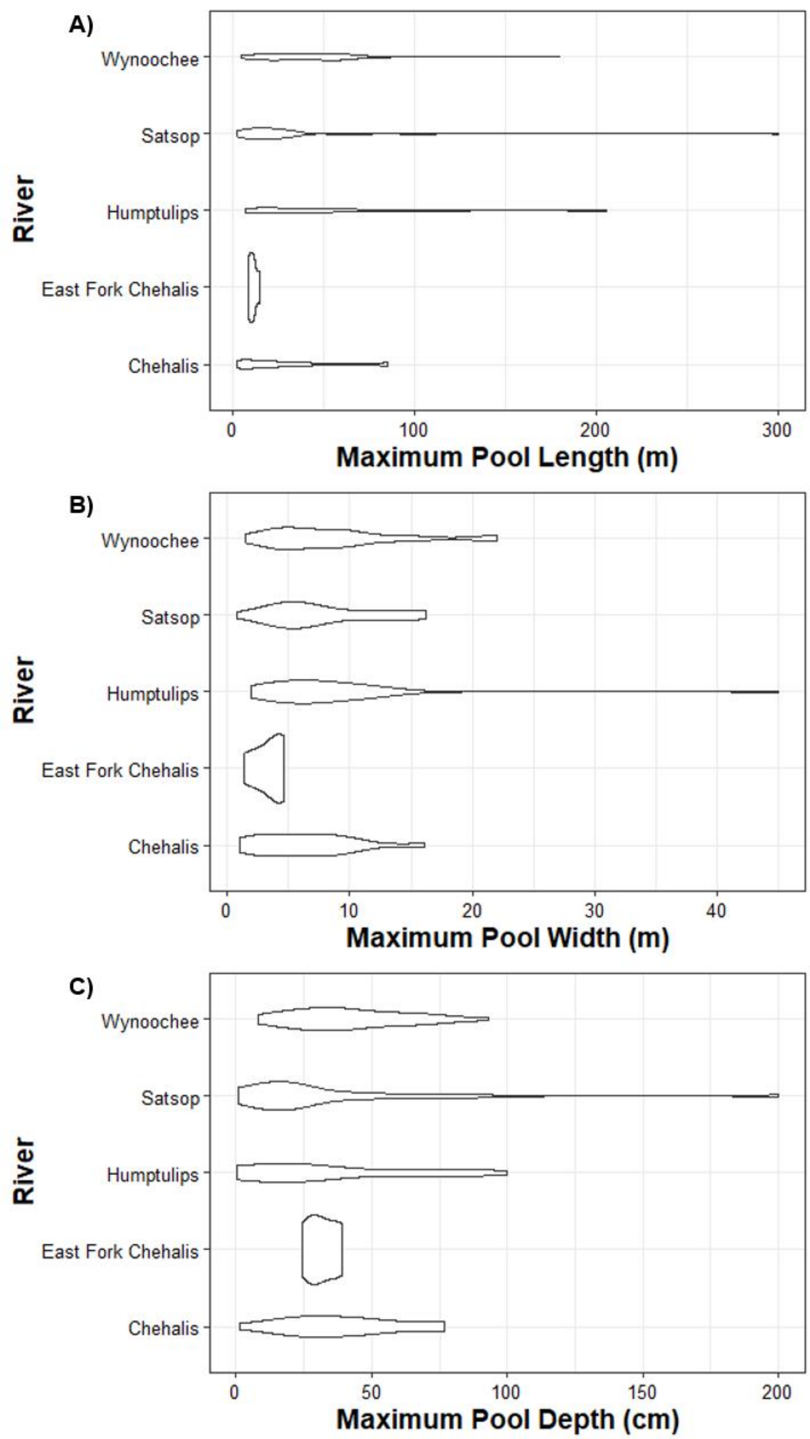
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Resurvey**	**Unique**
Survey Unit	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)
Black River			4.3 (6.9)						4.3 (6.9)
Cedar Creek			1.8 (2.9)						1.8 (2.9)
Elk Creek			2.9 (4.7)						2.9 (4.7)
Humptulips							23.3 (37.5)		23.3 (37.5)
-Brittain Creek							0.2 (0.3)		0.2 (0.3)
-East Fork Humptulips							11.2 (18.0)		11.2 (18.0)
-Stevens Creek							1.4 (2.2)		1.4 (2.3)
-West Fork Humptulips							22.7 (36.5)		22.7 (36.5)
Independence Creek			1.0 (1.5)						1.0 (1.6)
Katula Creek	0.2 (0.3)								0.2 (0.3)
Lincoln Creek			1.4 (2.3)						1.4 (2.3)
Newaukum River		7.0 (11.3)			14.8 (23.8)			9.8 (15.8)	12.0 (19.3)
-Lucas Creek					1.7 (2.7)				1.7 (2.7)
-Middle Fork Newaukum					6.2 (10.0)				6.2 (10.0)
-North Fork Newaukum					15.1 (24.3)				15.1 (24.3)
-South Fork Newaukum					25.1 (40.3)			3.4 (5.5)	21.7 (34.9)
Porter Creek			3.9 (6.3)						3.9 (6.3)
Satsop River		7.0 (11.3)		3.0 (4.9)		7.3 (11.7)		10.0 (16.1)	7.3 (11.7)
-Bingham Creek						0.9 (1.5)			0.9 (1.4)
-Canyon River						15.9 (25.6)			15.9 (25.6)
-Decker Creek						9.5 (15.3)			9.5 (15.3)
-East Fork Satsop						21.8 (35.1)			21.8 (35.1)
- Middle Fork Satsop						25.5 (41.1)			25.5 (41.0)
-West Fork Satsop						44.7 (72.0)			44.7 (71.9)
Scatter Creek			1.2 (1.9)						1.2 (1.9)

	2014	2015	2016	2017	2018	2019	2020	Resurvey	Unique
Survey Unit	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)	RM (RKm)
Skookumchuck River		4.7 (7.5)				23.0 (37.0)		4.6 (7.4)	23.1 (37.2)
South Fork Chehalis River			3.3 (5.4)	24.2 (39.0)				3.3 (5.3)	24.2 (38.9)
- Stillman Creek					7.9 (12.7)				7.9 (12.7)
Wynoochee River			6.3 (10.1)	45.4 (73.1)	20.1 (32.3)			14.9 (24.0)	56.9 (91.6)
Tributary Downstream Subtotals	**0.2 (0.3)**	**18.7 (30.1)**	**26.1 (42.0)**	**72.6 (117.0)**	**90.9 (146.1)**	**148.6 (239.3)**	**58.8 (94.5)**	**46.0 (74.0)**	**369.9 (595.3)**
Yearly Grand Totals All Areas	**28.7 (46.1)**	**35.0 (56.2)**	**89.9 (144.4)**	**73.2 (118.0)**	**142.0 (228.4)**	**148.9 (239.7)**	**58.8 (94.5)**	**64.3 (103.5)**	**512.2 (824.3)**

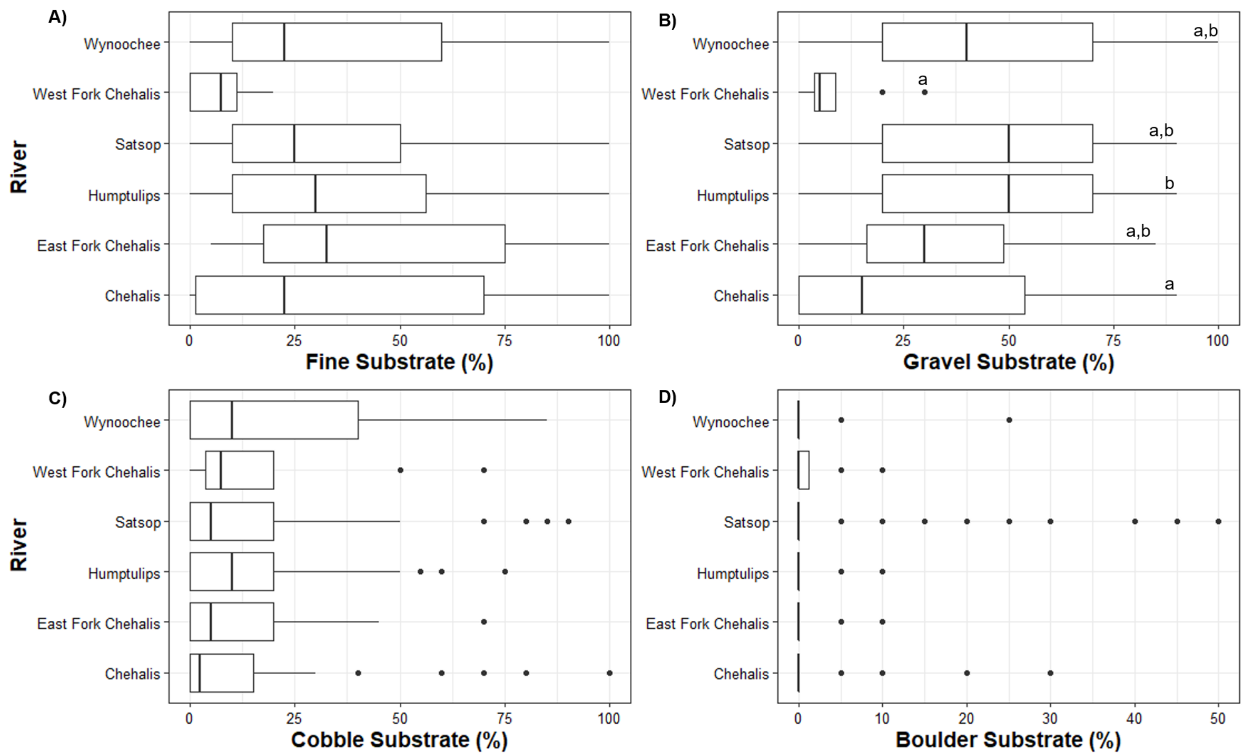
Supplemental Figures



Supplemental Figure 1. Water depth at oviposition sites within pools was relatively consistent among egg masses and did not differ among rivers. Most depth at egg masses were 10cm or shallower.



Supplemental Figure 2. Variation in maximum oviposition pool length (A), width (B), and depth (C). Average pool dimensions did not differ among rivers.



Supplemental Figure 3. Western toads oviposit over a diversity of a substrate compositions. Oviposition site variation in fine (A), gravel (B), cobble (C), and boulder (D) substrates. Substrate variation is generally variable across oviposition sites. Substrate differences among rivers were only different for gravel substrates (letters signify Tukey's post hoc groupings).